Constraining Ice-Phase Microphysical Processes Using GPM Observations

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Motivations

Using GPM satellite data to:

1. To validate cloud-resolving model simulations;

2. To understand ice-phase microphysical processes.

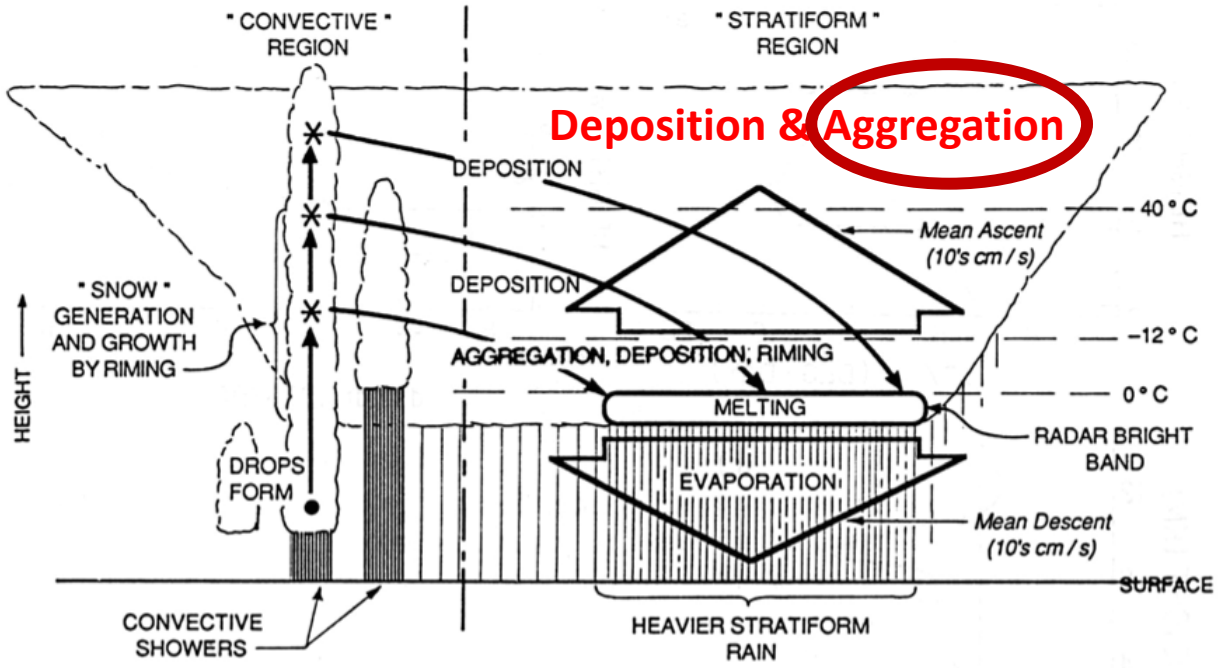
Obstacles:

- **Cloud-resolving models usually conduct case studies;**
- **Satellites observe many cases, but not necessarily THE case;**

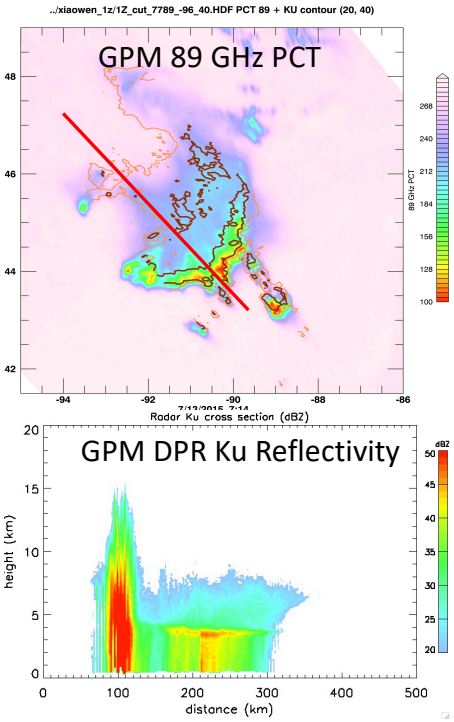
Assumptions:

- **There are fundamental processes that govern all precipitation cases;**
- **It is possible to isolate these processes under certain circumstances.**

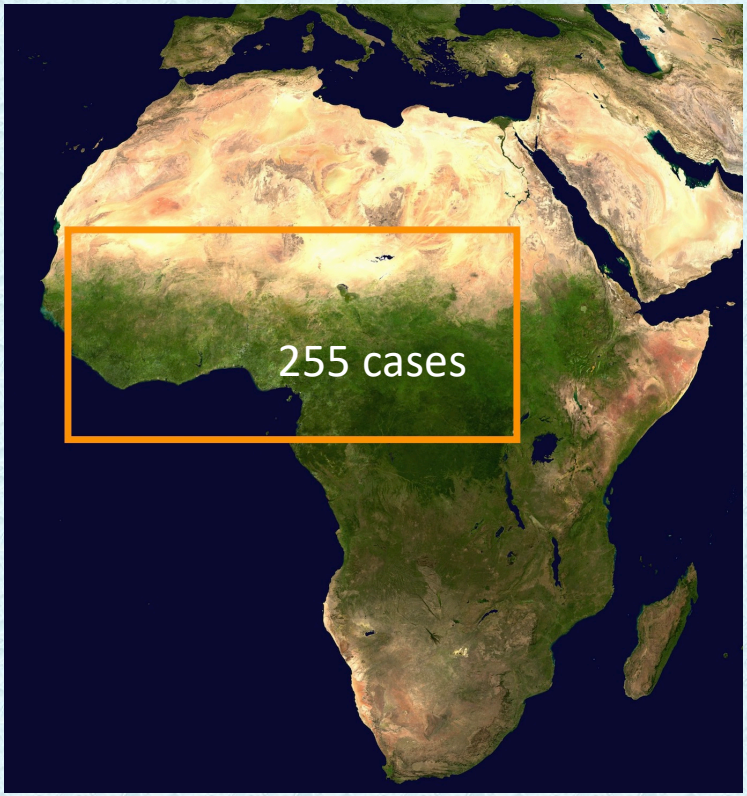
Mesoscale Convective System



Schematic MCS cross section with a trailing stratiform region, copied from Houze Jr. (1989, QJRMS).



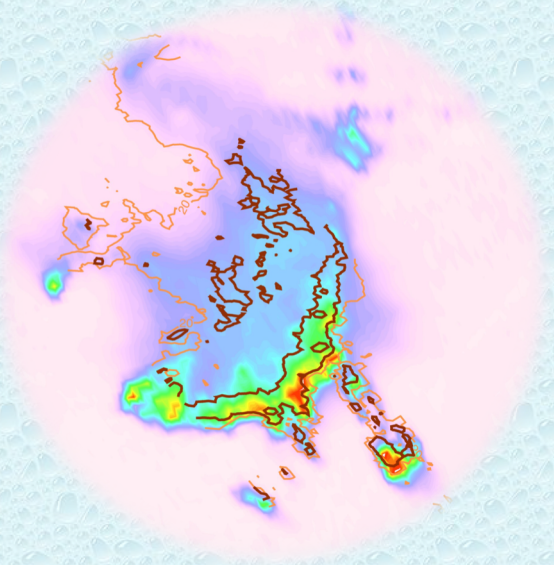
Case Selections



2014~2017, Summer months from May to August GPM Precipitation Features with >1000 contagious radar pixels.

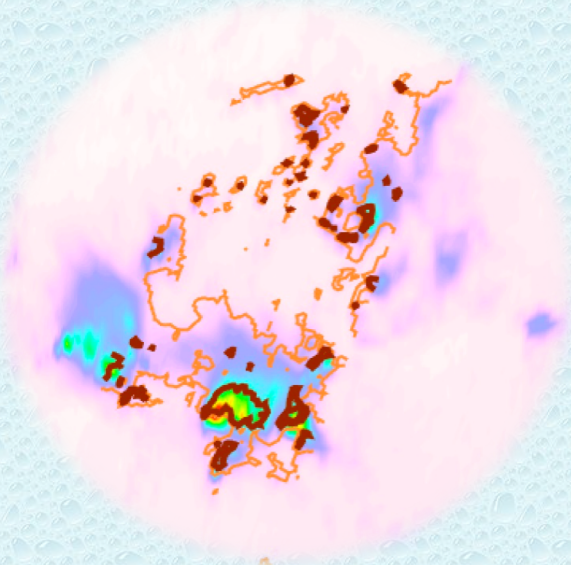
Types of Stratiform Rain

Squall Lines



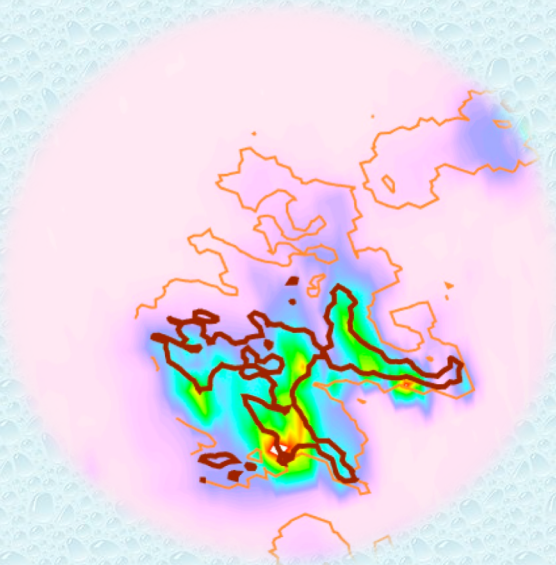
74 cases in West Africa
17 cases in North America

Organized MCSs



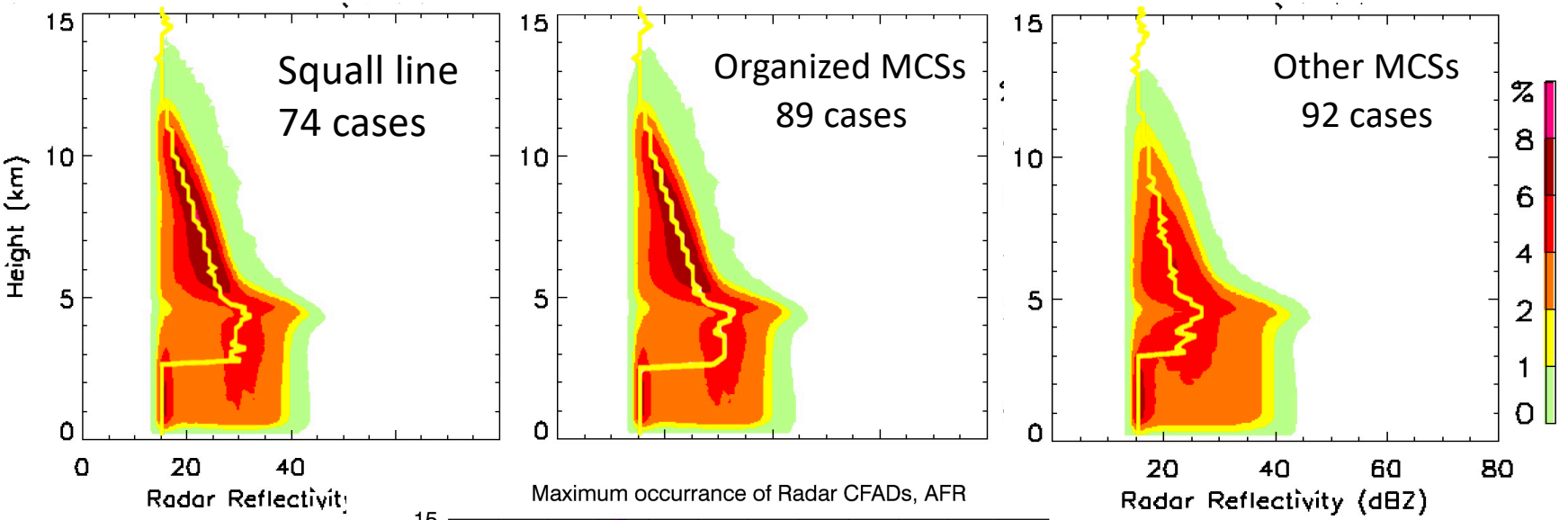
89 cases in West Africa
99 cases in North America

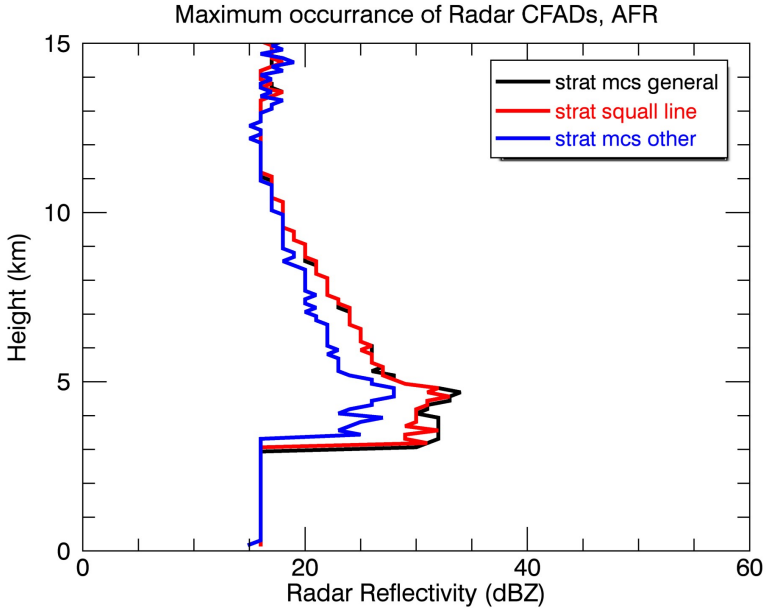
Other MCSs



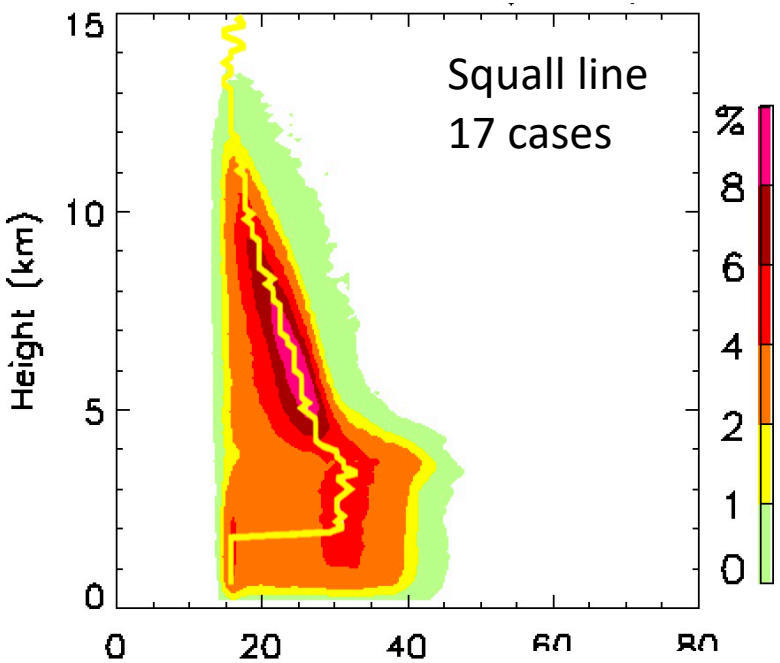
92 cases in West Africa
n/a in North America

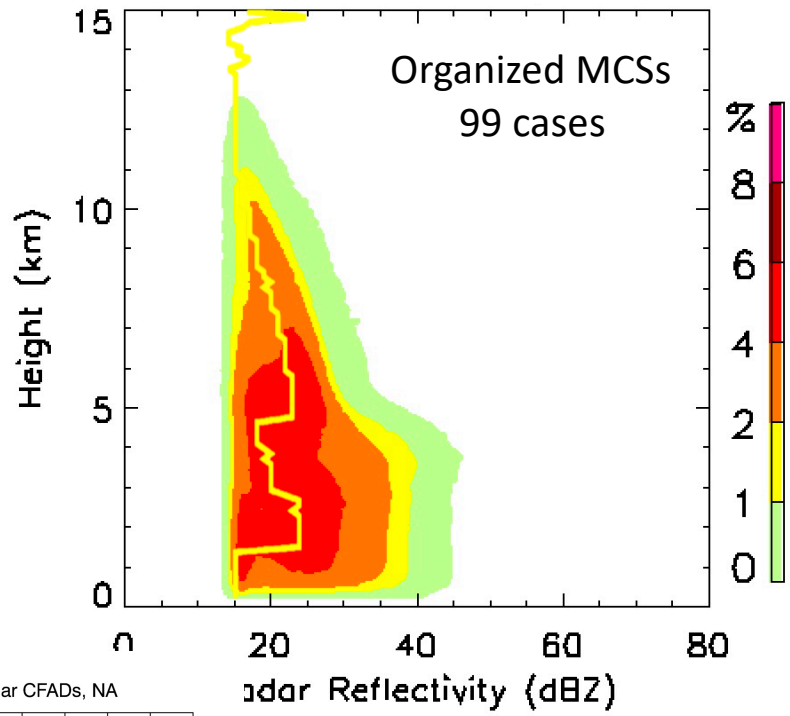
Ku Band Radar Reflectivity CFADs in Stratiform Region (West Africa)

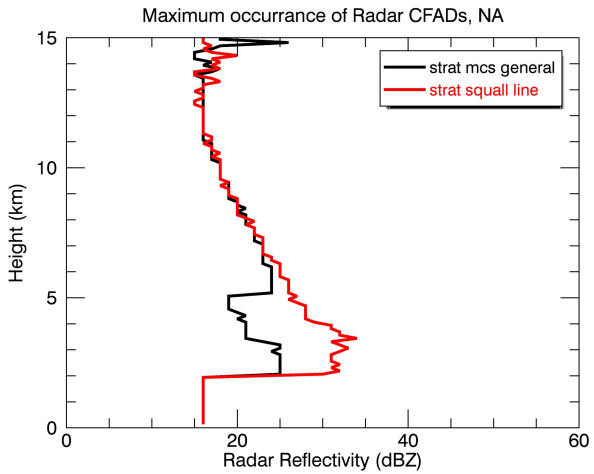




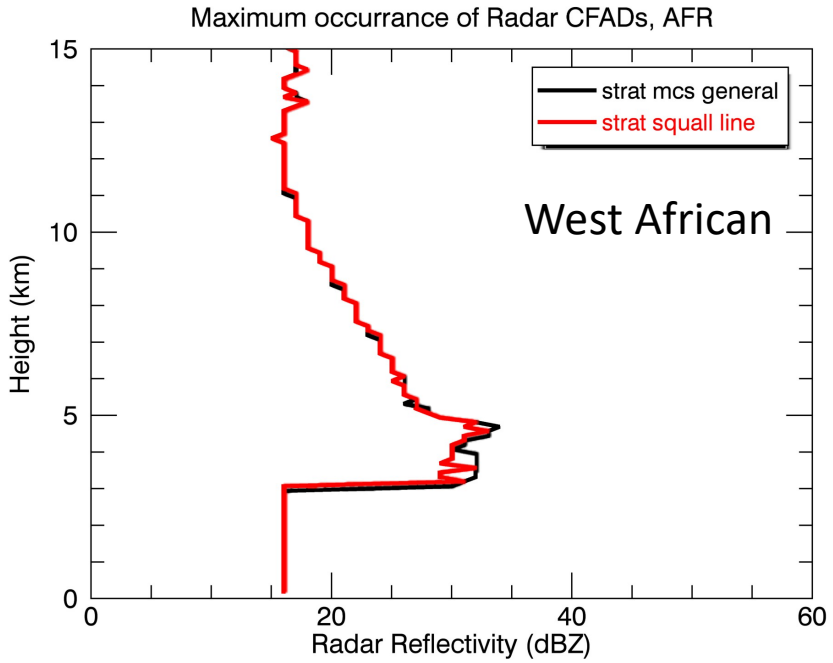
Ku Band Radar Reflectivity CFADs in Stratiform Region (North America)

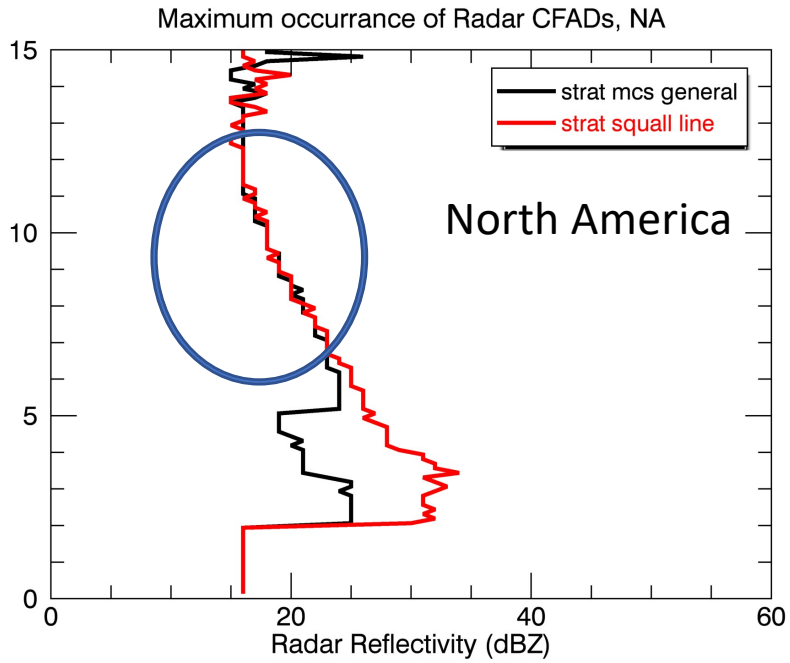




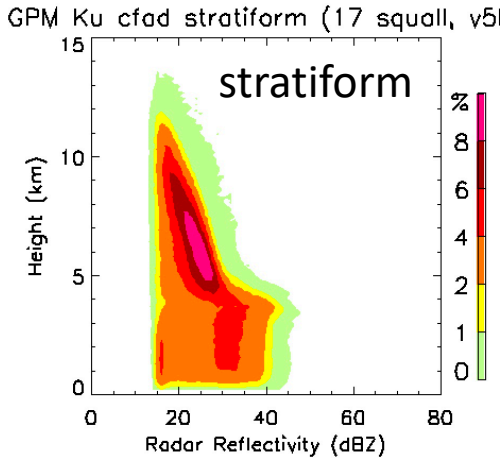


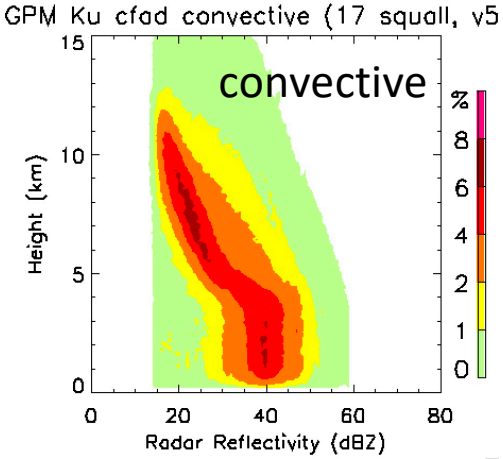
Stratiform region in MCSs have robust radar reflectivity profiles, likely due to the same process(es) (coalescence?). Radar CFADs and maximum CFAD profiles can be used for model validations.

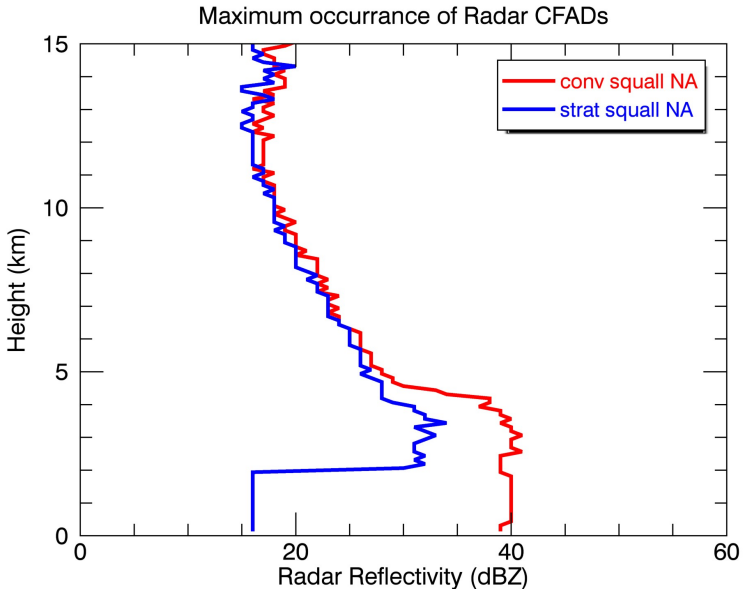


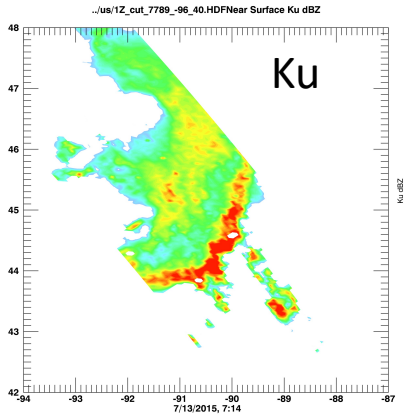


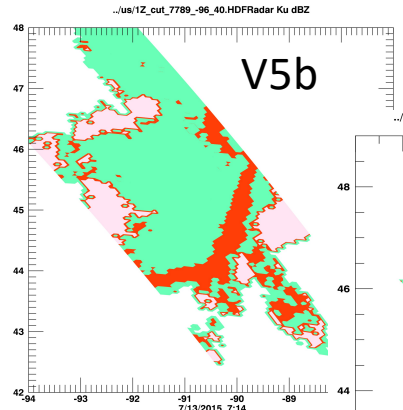
Convective/Stratiform Separation (mis-classification? – or not?)

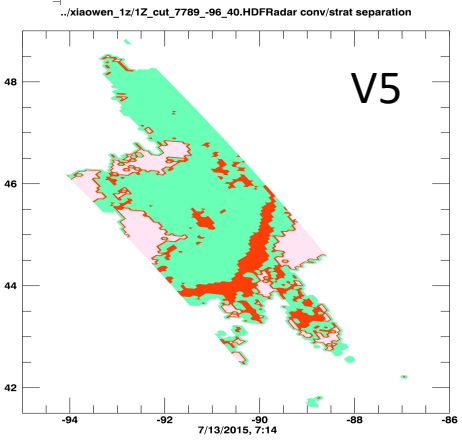




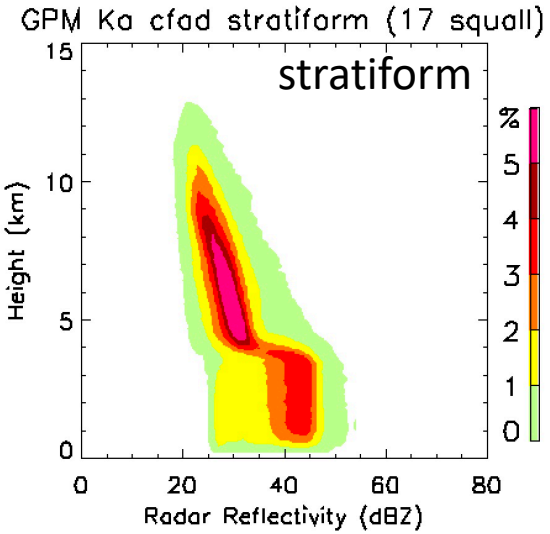


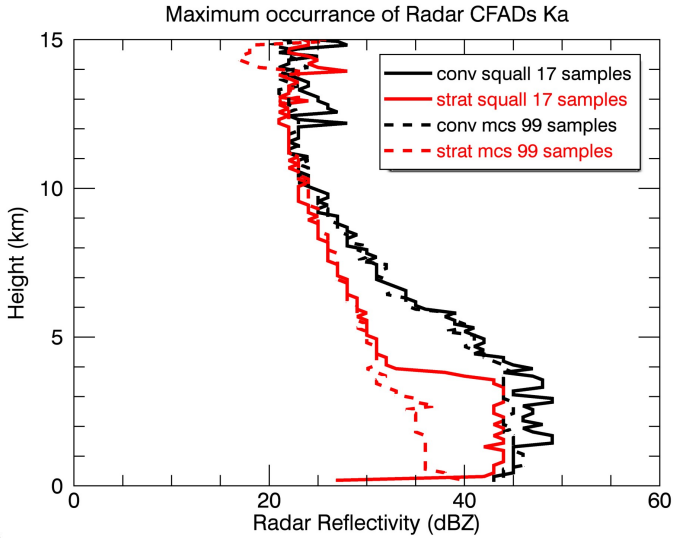


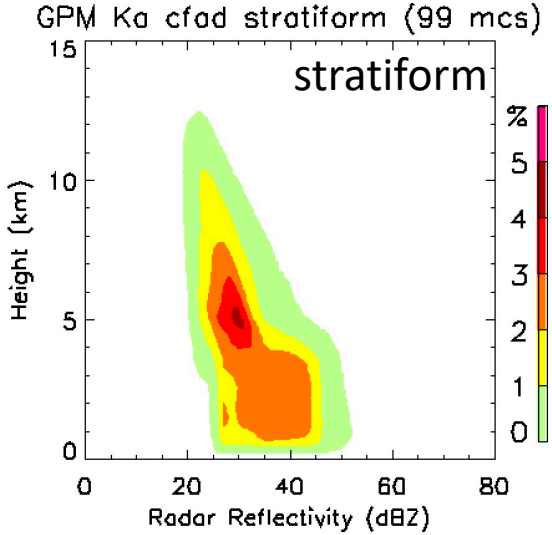


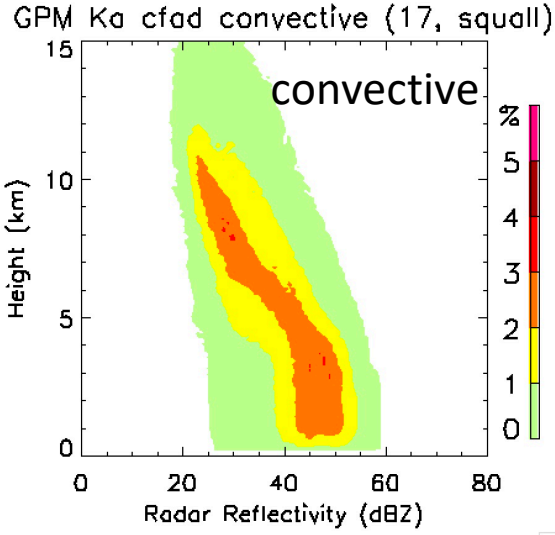


Convective/Stratiform Separation (Ka CFADs behave differently than Ku CFADs)



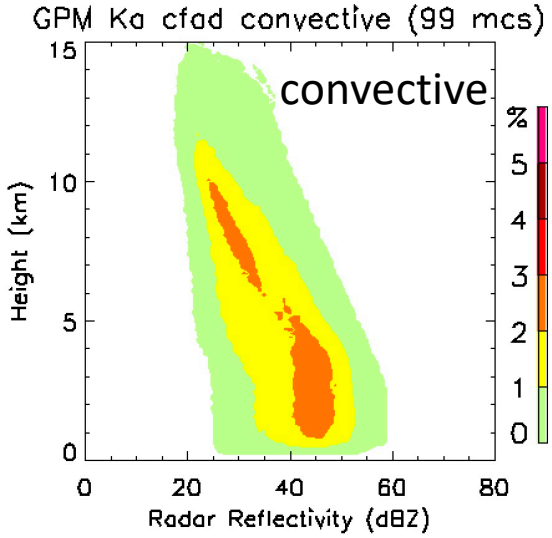






Ka band reflectivity CFADs show reasonable convective separations, indicating the separation algorithm may be fine. Why?

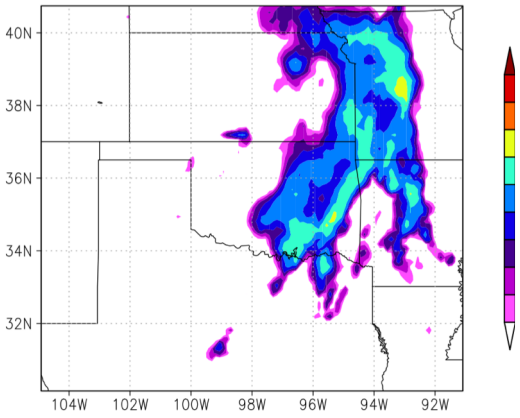
- Ka sensitive to smaller particles?
- Attenuation correction?
- Coincident?



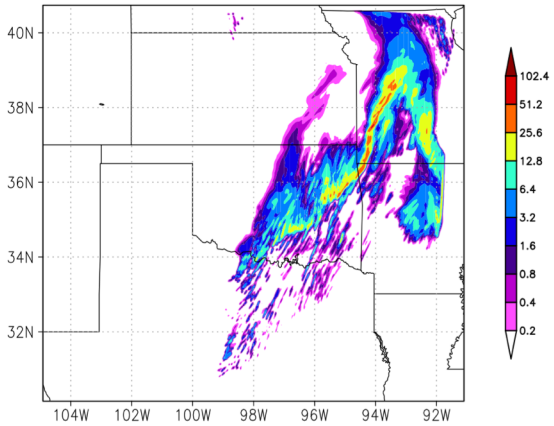
WRF Model Simulations of MC3E May 20 Case

WRF v3.6.1 single domain with 1km horizontal resolution and 47 vertical levels. The models were integrated for 24 hours, starting from May 20 at 00 UTC, 2011. Initial conditions used NCDP FNL Analysis. Microphysical schemes used the Hebrew University spectral bin scheme (**SBM**), which explicitly simulates particle size distributions, and the Morrison scheme, which assumes exponential particle size distributions for ice-phase particles (**Morrison**).

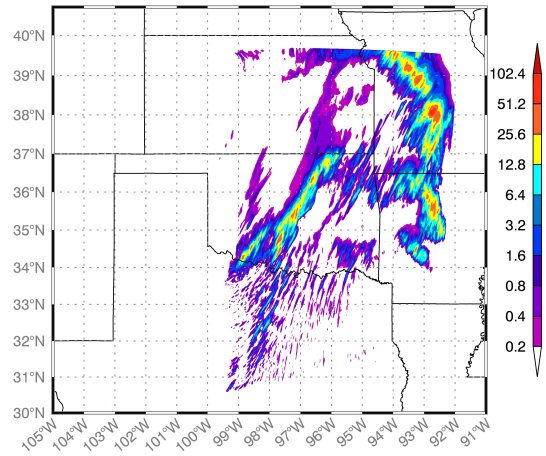
Surface Rainfall Observation



Morrison Control

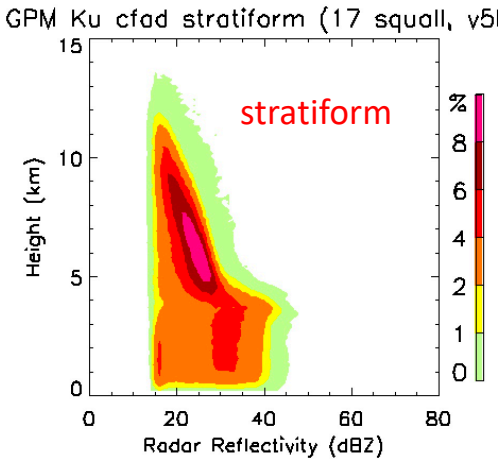


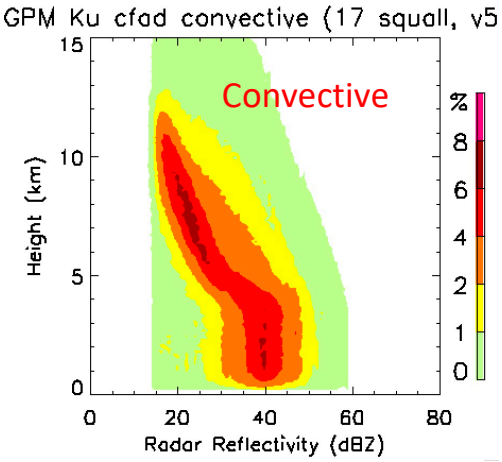
SBM Control



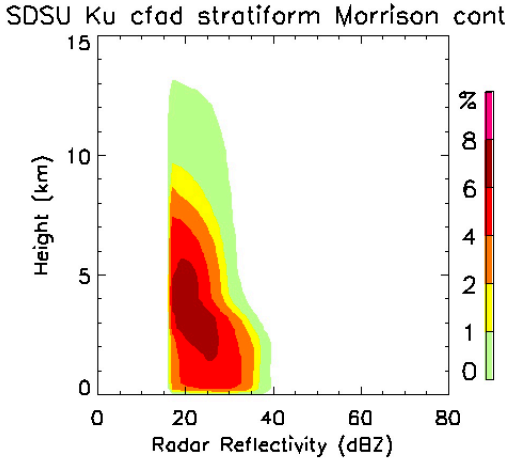
Goddard Satellite Satellite Data Simulator (GSDSU)
Ku- Band Reflectivity CFADs Comparisons with GPM Data

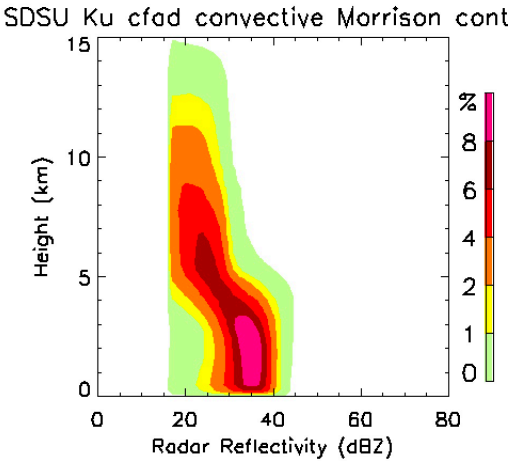
Ku CFADs
Observation



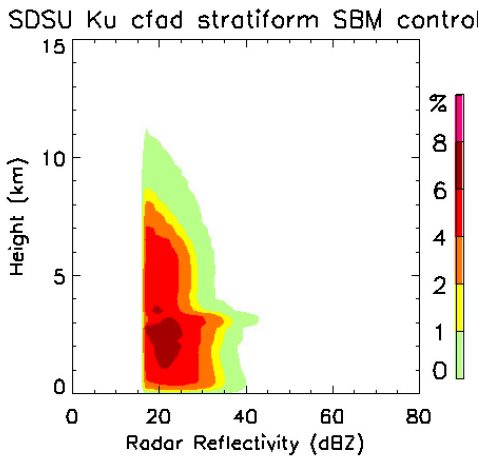


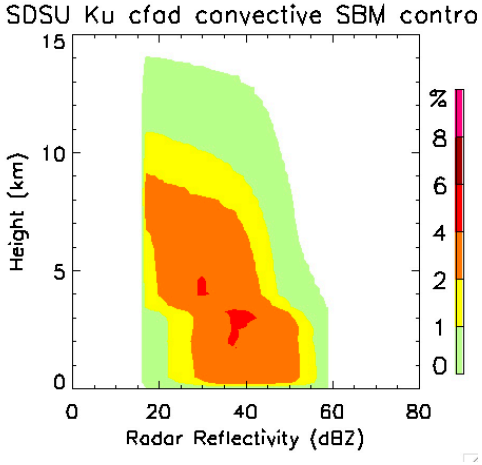
Morrison Scheme
Ku CFADs



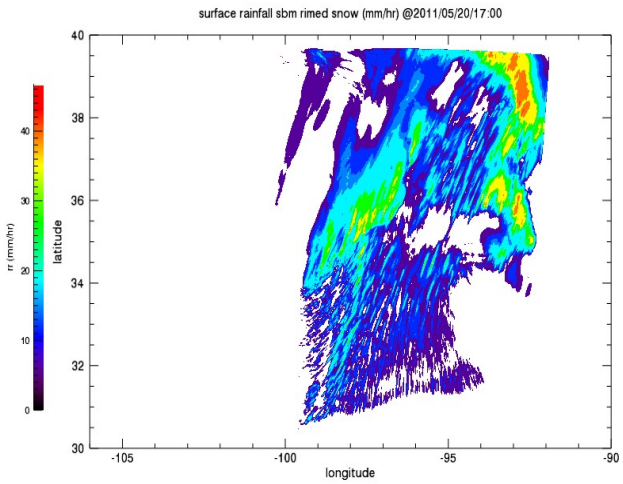


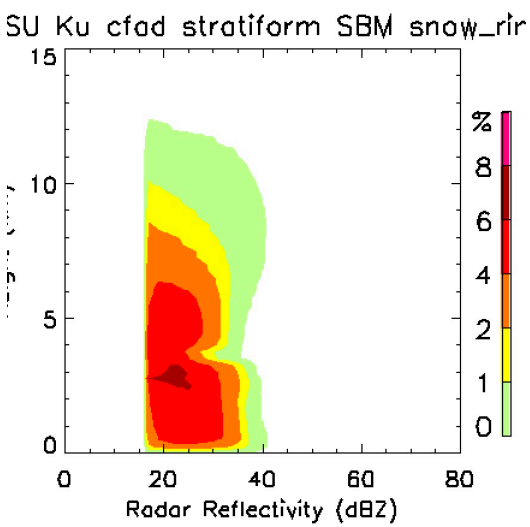
SBM control
Ku CFADs

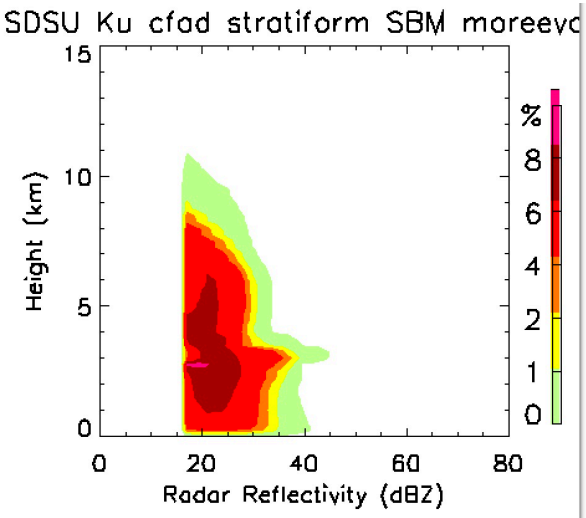


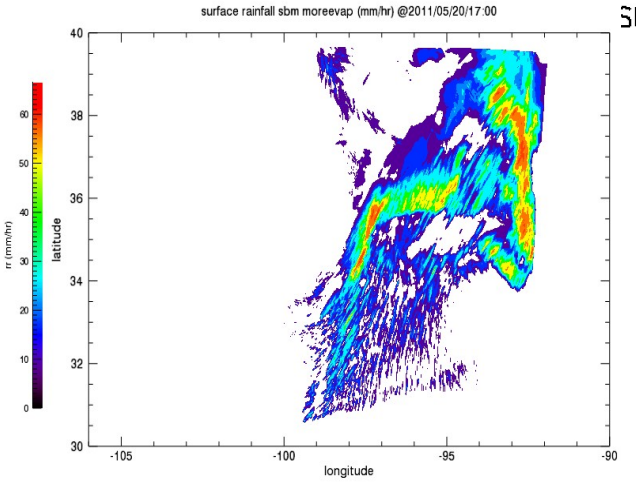


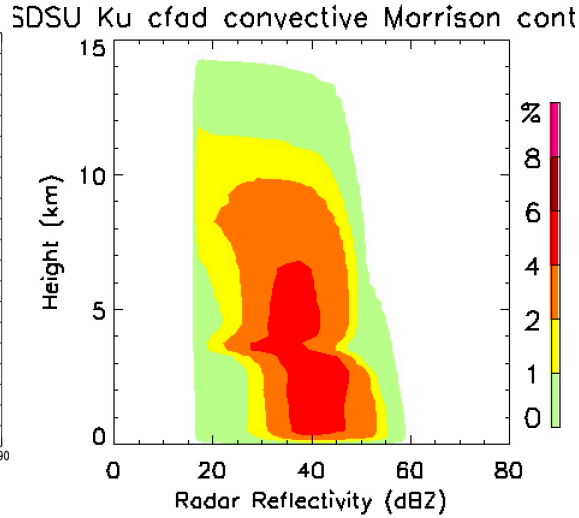
WRF sensitivity tests with the goal of increasing stratiform region area

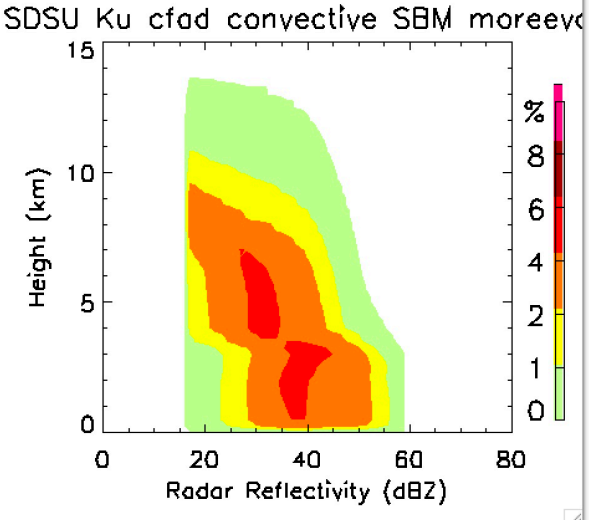










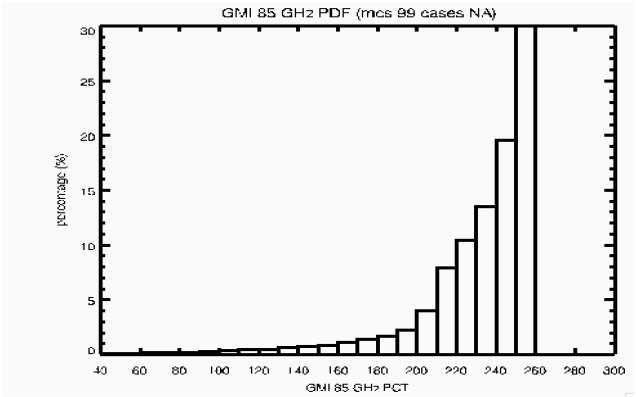


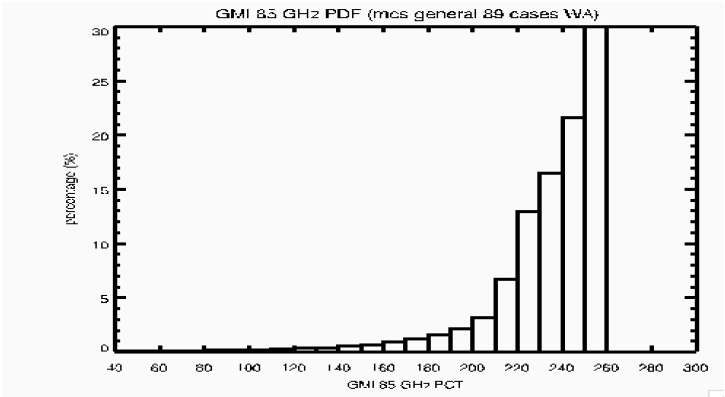
Simulated Surface Rainfall

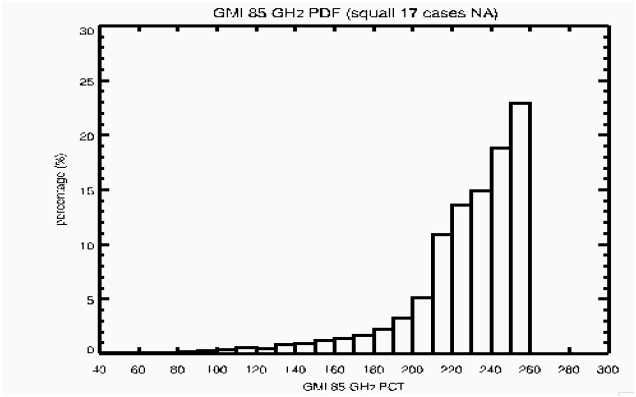
CFADs for snow rimming sensitivity test

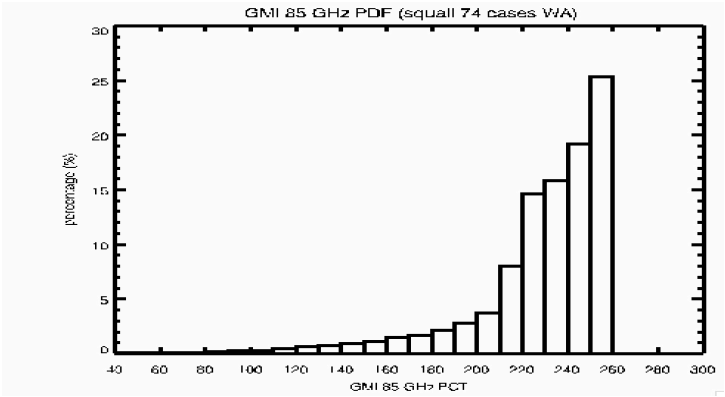
CFADs for rain evaporation sensitivity test

GMI can provide further information









Conclusions and Future work

- MCS stratiform region can provide fairly consistent signals for model validation, e.g., ice particle coalescence process;
- Future work will include model simulations to understand the sensitivity of the microphysics and match simulated GPM signals to observed statistics.